Laboratories for the 21st Century – *An Overview*

Revised: 9 Dec 04

Why Focus on Laboratories?

- Laboratories are energy intensive.
  - On a square foot basis, labs often consume ten times as much energy as a typical office building.
- Most existing labs can reduce energy use by 30% or more with existing technology.
- Reducing laboratory energy use will significantly reduce greenhouse gas emissions.
- Energy cost savings possible from U.S. labs may be as much as $2.4 billion annually.
- Labs are typically not speculative buildings—informed owners are more likely to invest with lifecycle costs in mind.

Whole Building Design Approach *for* Laboratories

- Optimize overall laboratory performance through integrated design and engineering with a life-cycle cost perspective.
- Avoid the traditional approach of optimizing components based on narrowly defined functions.
- Consider benefits of sustainability.

Sustainability – Beyond Energy

- Water conservation and recovery
- Building materials reduction, reuse, and recycling
- Health and safety risk management
- Innovations in chemical management
- Building for flexibility in design

Laboratories for the 21st Century – Labs21 Basics

- Adopt aggressive low-energy design and operation targets.
- Assess opportunities from a “whole buildings” approach.
- Use life-cycle cost decision-making.
- Commission equipment and controls.
- Employ a broad range of sustainable energy and water efficiency strategies.
- Measure energy and water consumption and track emission reductions.

Laboratories for the 21st Century – Labs21 Basics…

- Evaluate on-site power generation, combined heat and power technologies, and renewable power purchases.
- Specify “green” construction materials.
- Promote energy and water efficiency operation and training efforts.
- Explore sustainable design opportunities beyond the building site.
  - For example, campus-wide utility or mass transit projects.

What is the Labs21 Program?

- A joint EPA/DOE program to improve the environmental performance of U.S. laboratories.
- The goal of the program is to encourage the design, construction, and operation of sustainable, high-performance, facilities that will:
  - Minimize overall environmental impacts.
  - Protect occupant safety.
  - Optimize whole building efficiency on a life-cycle basis.

Labs21 Program Components

- Pilot Partnership Program
  - Draws together lab owners and operators committed to implementing high performance lab design.
- Training Program
  - Includes annual technical conference, training workshops, and other peer review opportunities.
- Best Practices and Tool Kit
  - An Internet-accessible compendium of case studies and other information on lab design and operation, building on the *Design Guide for Energy Efficient Research Laboratories* developed by Lawrence Berkeley National Laboratory, and more...

Partnership Program

- Private-Sector Partners
  - Bristol-Myers Squibb
  - Carnegie Mellon University
  - Duke University
  - Harvard University
  - Raytheon Company
  - University of California-Merced
  - University of Hawaii
  - University of North Carolina-Asheville
  - Wyeth-Ayerst Pharmaceuticals
  - New York City School Construction Authority
- Federal partners:
  - Lawrence Berkeley National Laboratory
  - National Renewable Energy Laboratory
  - National Oceanic & Atmospheric Administration
  - Sandia National Laboratories
  - U.S. Environmental Protection Agency

Labs21 Training Program

- Workshop Course Topics

  Architecture of High-Performance Laboratories

  Engineering and Energy-Efficient Lab Design

  Air Supply and Distribution Systems

  Laboratory Exhaust Systems

  Commissioning and Direct Digital Controls

  Lighting and Daylighting

  Sustainability and Green-Design Techniques

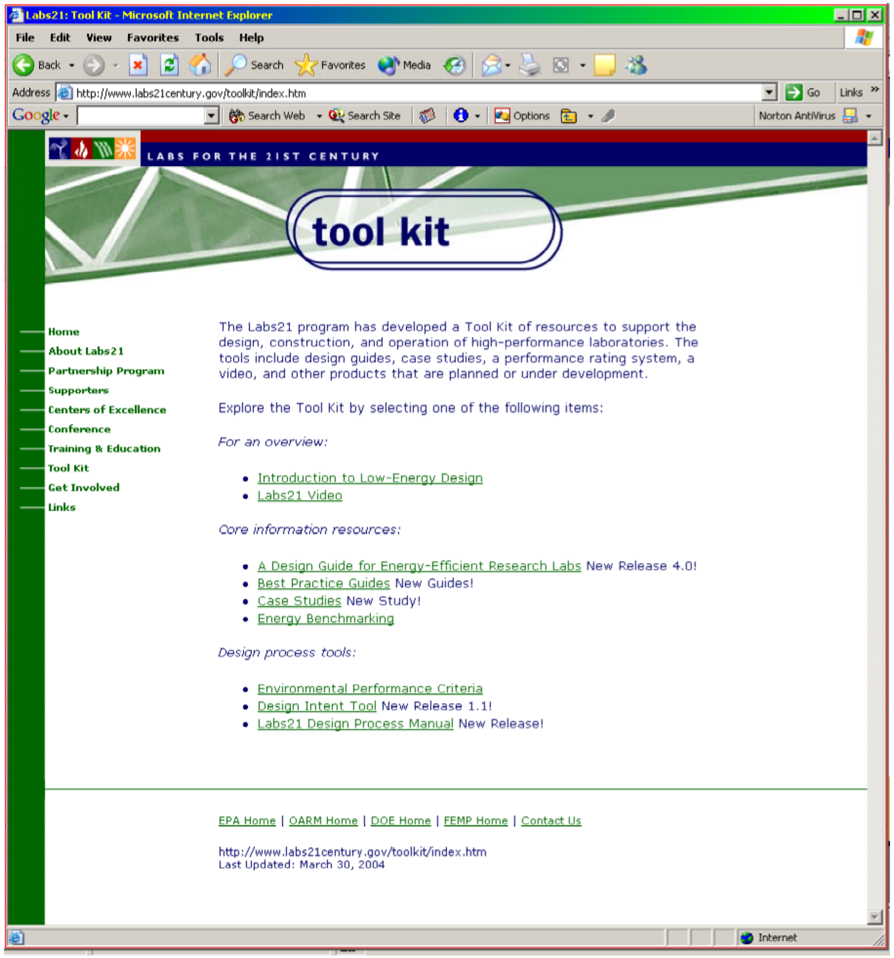
  Case Studies

  Resources and Tools

Labs21 Best Practices
Environmental Performance Criteria (EPC)
Based on US Green Building Council's LEED™ Rating System

- Sustainable Sites
  - Safety and Risk Management
- Water Efficiency
  - Laboratory Equipment Water Use
  - Process Water Efficiency
- Energy and Atmosphere
  - Minimum Energy Performance
  - Minimum Ventilation Requirements
  - Optimize Energy Efficiency
  - Renewable Energy
  - Energy Supply Efficiency
  - Improved Laboratory Equipment Efficiency
  - Right-Sizing Laboratory Equipment Load
- Materials and Resources
  - Hazardous Materials Handling
  - Chemical Resource Management
- Indoor Environmental Quality
  - Laboratory Ventilation
  - Exterior Door Notification System
  - Controllability of Systems
  - Indoor Environmental Safety
- Innovation and Design Process

Labs21 Tool Kit



Recapping…

Benefits of the Labs21 Approach

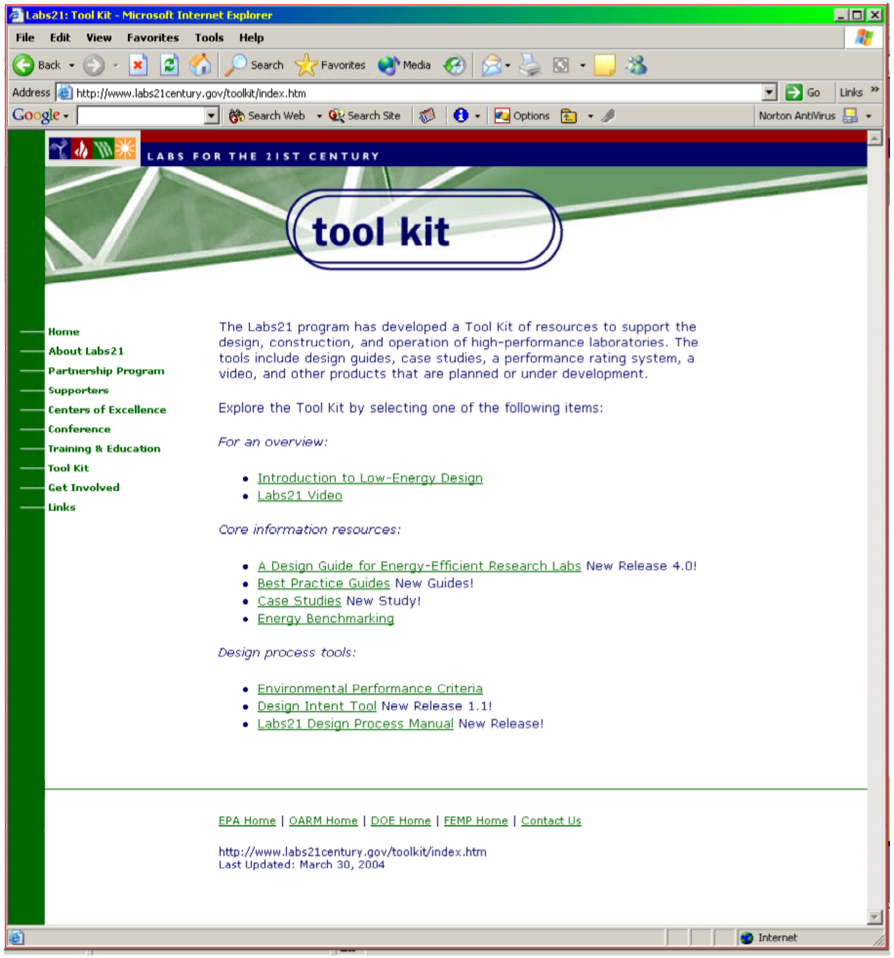
- Reduce operating costs.
- Improve environmental quality.
- Expand capacity.
- Increase health, safety, and worker productivity.
- Improve maintenance and reliability.
- Enhance community relations.
- Maintain recruitment and retention of scientists.

Sustainable Design Process using the Labs21 Toolkit

Tools and Process

- Sustainable design process
  - Seamlessly integrates sustainability into the decision-making process
  - Team-based approach
- The Labs21 toolkit is an interlinked set of tools that can effectively support a sustainable design process
- The toolkit does not prescribe a fixed process
- Tools are interlinked but can be used independently if desired.

Labs21 Tool Kit



The Toolkit

- *Overview resources*
  - Intro to Low-Energy Design
  - Labs21 Video
- *Core information resources*
  - A Design Guide for Energy-Efficient Research Labs, Ver. 4.0
  - Best Practice Guides *(New Guide)*
  - Case Studies *(New Studies)*
  - Energy Benchmarking
- *Design process tools*
  - Labs21 Process Manual *(New Release)*
  - Design Intent Tool, Version 1.1
  - Environmental Performance Criteria

Two Sources: Toolkit CD, Labs21 website

Overview resources

Intro to Low-Energy Design

LABORATORIES FOR THE 21ST CENTURY:
AN INTRODUCTION TO LOW-ENERGY DESIGN

As a building type, the laboratory demands our attention: what the cathedral was to the 14th century, the train station was to the 19th century, and the office building was to the 20th century, the laboratory is to the 21st century. That is, it is the building type that embodies, in both program and technology, the spirit and culture of our age and attracts some of the greatest intellectual and economic resources of our society.

Unfortunately, a laboratory is also a prodigious consumer of natural resources. For example, laboratories typically consume 5 to 10 times more energy per square foot than do office buildings. And some specialty laboratories, such as cleanrooms and labs with large process loads, can consume as much as 100 times the energy of a similarly sized institutional or commercial structure.

The challenge for architects, engineers, and other building professionals is to design and construct the next generation of laboratories with energy efficiency, renewable energy sources, and sustainable construction practices in mind. And to do so while maintaining — and even advancing — high contemporary standards of comfort, health, and safety.

If we are successful, the benefits will be significant. Assuming that half of all American laboratories can reduce their energy use by 30%, the U.S. Environmental Protection Agency (EPA) estimates that the nation could reduce its annual energy consumption by 84 trillion Btu. This is equivalent to the energy consumed by 840,000 households. An improvement of this magnitude would save $1.25 billion annually and decrease carbon dioxide emissions by 19 million tons — equal to the environmental effects of removing 1.3 million cars from U.S. highways or preventing 56 million trees from being harvested.

Daylighting enhances the scientists' work space at the Fred Hutchinson Cancer Research Center in Seattle, Washington.

With these benefits in mind, this publication describes some energy-efficient strategies for designing and equipping the laboratories of the 21st century. It introduces the basic issues associated with energy consumption in the laboratory and summarizes key opportunities to improve or optimize energy performance during each phase of the design and acquisition process. Both standard and advanced new technologies and practices are included.

EPA United States Environmental Protection Agency

FEDERAL ENERGY MANAGEMENT PROGRAM

Overview resources

Labs21 Video

"Labs embody the spirit, culture, and economy of our age…what the cathedral was to the 14th century and the office building was to the 20th century, the laboratory is to the 21st century."

Don Prowler

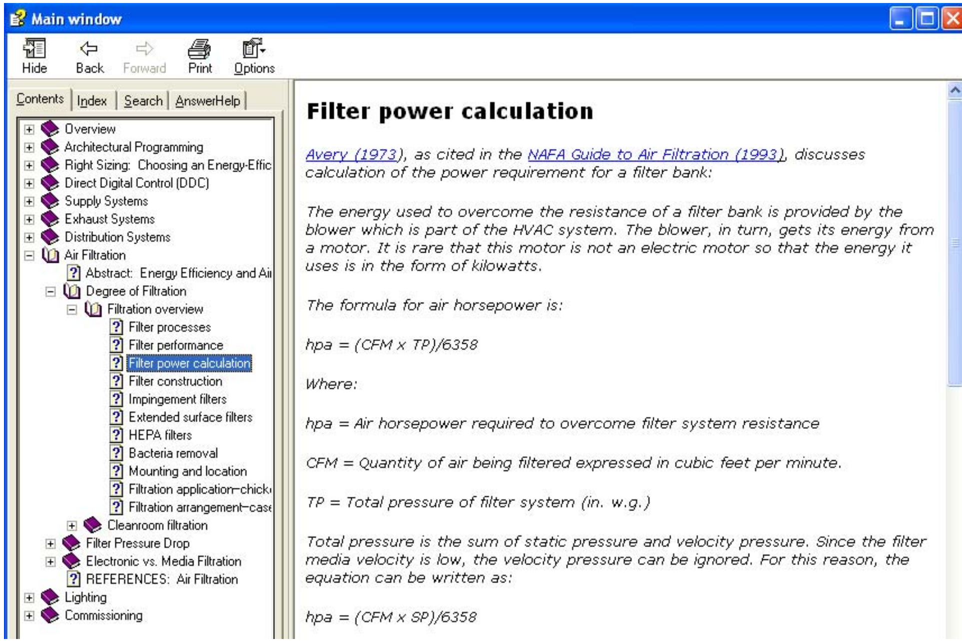
College of Engineering, Rowan University

Core information resources

Design Guide for Energy-Efficient Laboratories

- A searchable, detailed reference on high-performance, low-energy lab design and operation

- 4-level hierarchy – from general to specific
  - Level 1: Major topics
    - E.g. Exhaust Systems
  - Level 2: Sub topics
    - E.g. VAV fumehoods
  - Level 3: Components
    - E.g. VAV fumehood face velocity control
  - Level 4: Background/Supporting information
    - E.g. Fume Hood Face Velocity Response Time



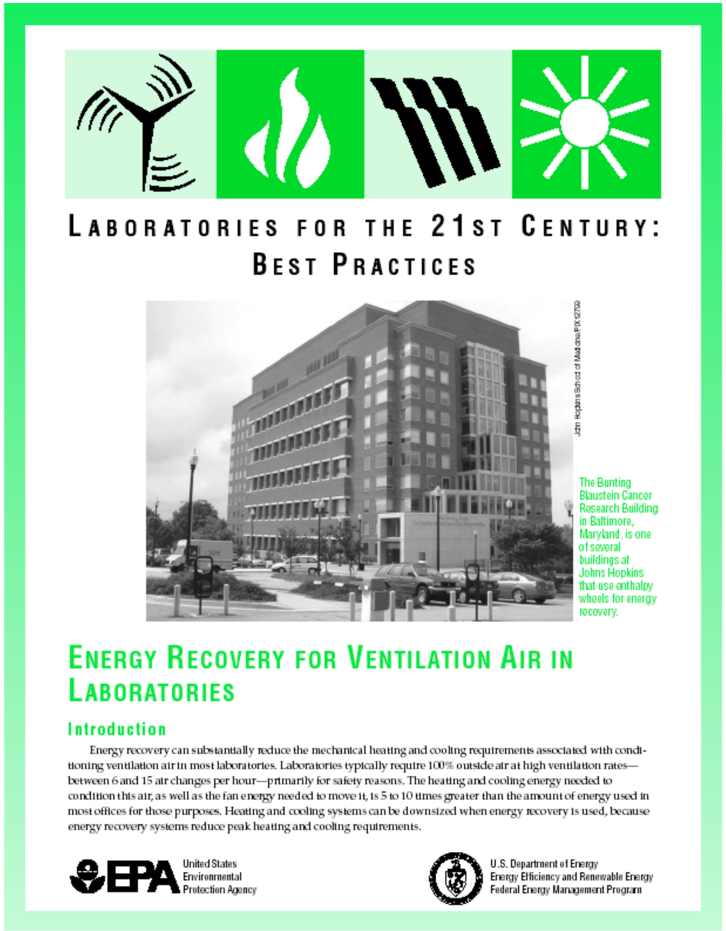
Core information resources

Design Guide for Labs - Contents

Core information resources

Best Practice Guides

- Describes how to implement a strategy, with implementation examples
- Completed guides:
  - Daylighting in Laboratories
  - Energy Recovery
  - On-Site Combined Heat and Power
- Several in development
  - Labs21 seeking contributing authors



LABORATORIES FOR THE 21ST CENTURY: BEST PRACTICES

The Bunting Blaustein Cancer Research Building in Baltimore, Maryland, is one of several buildings at Johns Hopkins that use enthalpy wheels for energy recovery.

ENERGY RECOVERY FOR VENTILATION AIR IN LABORATORIES

Introduction

Energy recovery can substantially reduce the mechanical heating and cooling requirements associated with conditioning ventilation air in most laboratories. Laboratories typically require 100% outside air at high ventilation rates—between 6 and 15 air changes per hour—primarily for safety reasons. The heating and cooling energy needed to condition this air, as well as the fan energy needed to move it, is 5 to 10 times greater than the amount of energy used in most offices for those purposes. Heating and cooling systems can be downsized when energy recovery is used, because energy recovery systems reduce peak heating and cooling requirements.

EPA United States Environmental Protection Agency

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Federal Energy Management Program

Core information resources

Case Studies

- Sandia National Laboratories PETL
- National Institutes of Health Building 50
- Fred Hutchinson Cancer Research Center
- Georgia Public Health Laboratory
- U.S. EPA National Vehicle and Fuel Emissions Lab
- Pharmacia Building Q
- Nidus Center
- Bren Hall

All case studies have whole-building and system level energy use data

LABORATORIES FOR THE 21ST CENTURY: CASE STUDIES

Case Study Index

Laboratory Type
- ☑ Wet lab
- ☑ Dry lab
- ☐ Clean room

Construction Type
- ☑ New
- ☐ Retrofit

Type of Operation
- ☐ Research/development
- ☐ Manufacturing
- ☑ Teaching
- ☑ Chemistry
- ☑ Biology
- ☐ Electronics

Service Option
- ☑ Suspended ceiling
- ☐ Utility service corridor
- ☐ Interstitial space

Featured Technologies
- ☑ Fume hoods
- ☑ Controls
- ☑ Mechanical systems
- ☑ Electrical loads
- ☑ Water conservation
- ☑ Renewables
- ☑ Sustainable design/planning
- ☐ On-site generation
- ☑ Daylighting
- ☑ Building commissioning

Other Topics
- ☐ Diversity factor
- ☐ Carbon trading
- ☐ Selling concepts to stakeholders
- ☑ Design process

LEED Rating
- ☑ Platinum
- ☐ Gold
- ☐ Silver
- ☐ Certified

DONALD BREN HALL, SANTA BARBARA, CALIFORNIA

Introduction

The Donald Bren School of Environmental Science & Management at the University of California, Santa Barbara (UCSB) "walks the talk" and exemplifies its mission. Because of its many energy-efficient and environmentally sound features, Donald Bren Hall has received a Platinum rating—the highest—under the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED)™ rating system (Version 1.0). In October 2003, this building was one of only two certified Platinum in the nation, and it is the only laboratory to achieve this level of recognition.

The mission of the Donald Bren School is "to play a leading role in researching environmental issues, identifying and solving environmental problems and training research scientists and environmental management professionals." The school trains graduate students in rigorous,

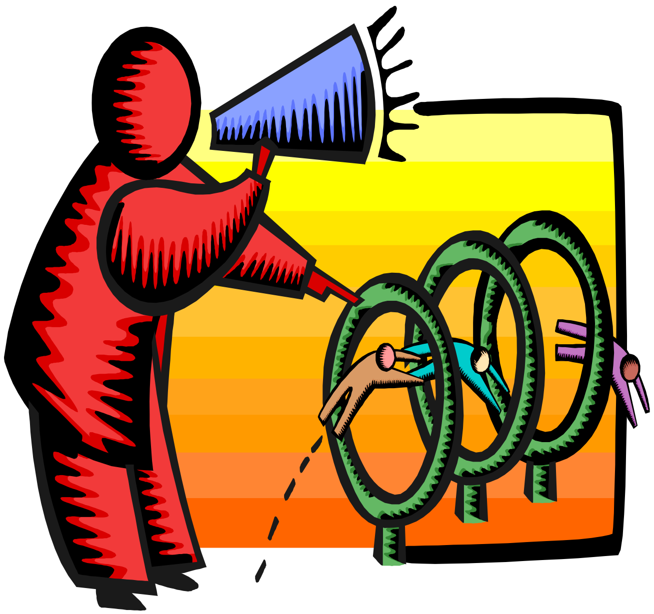
United States Environmental Protection Agency

U.S. Department of Energy Energy Efficiency and Renewable Energy Federal Energy Management Program

Core information resources

Energy Benchmarking Tool

- National database of lab energy use data
  - Web-based input and analysis
  - About 40 facilities
- Why benchmark during design?
  - See where you stand
  - Set targets
    - Building level (e.g. Site BTU/sf)
    - System level (e.g. W/cfm)



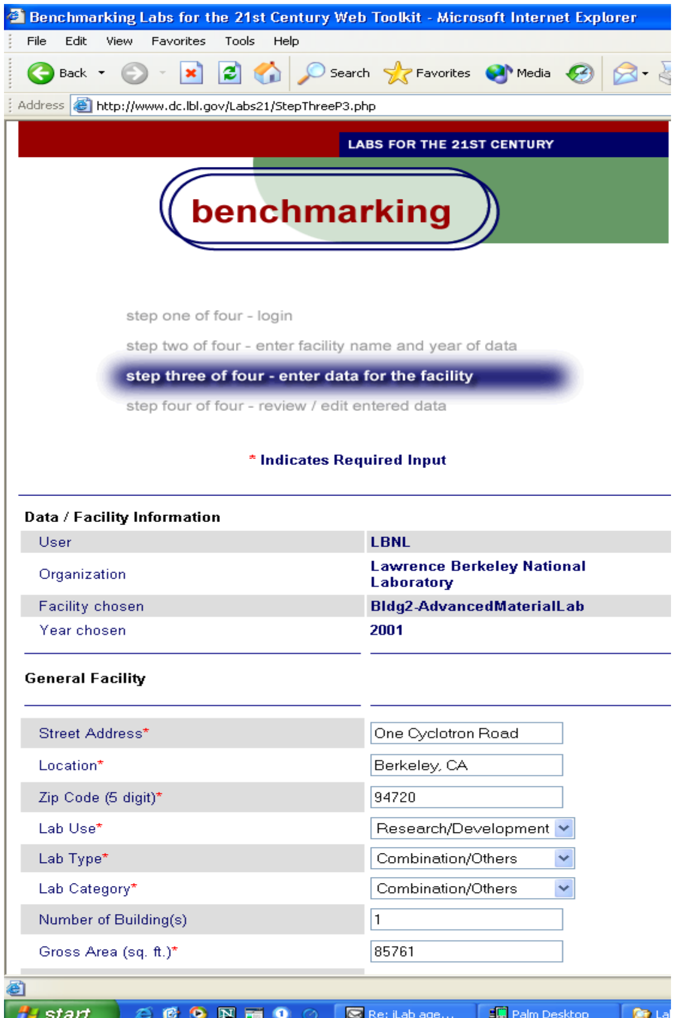
Core information resources

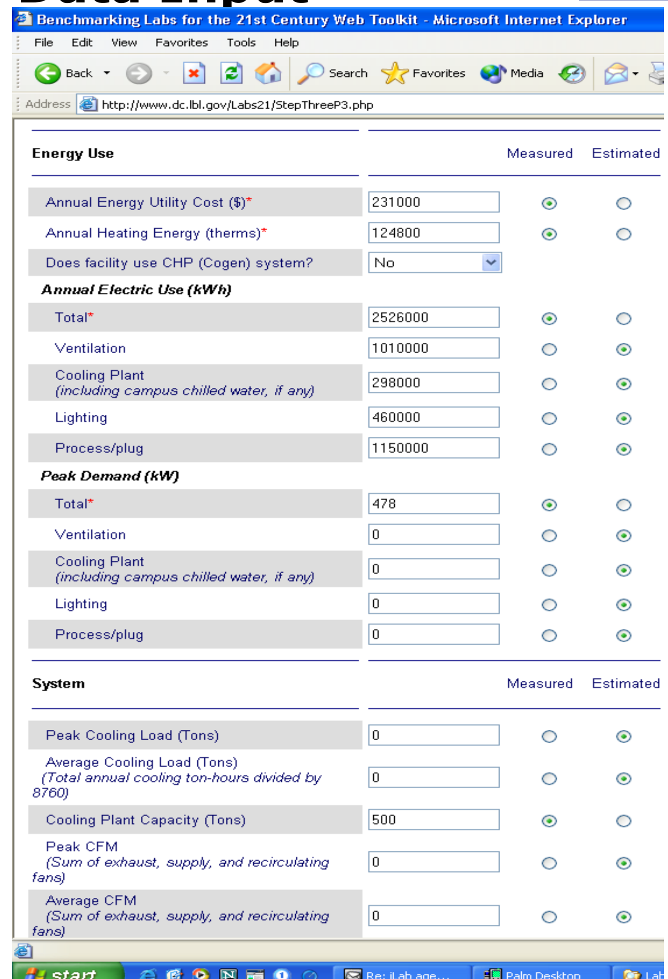
Benchmarking Metrics

System	Energy Consumption	Energy Demand
Ventilation	kWh/sf-yr	Peak W/cfm Peak cfm/sf (lab) Avg cfm/peak cfm
Cooling	kWh/sf-yr	Peak W/sf Peak sf/ton
Lighting	kWh/sf-yr	Peak W/sf
Process/Plug	kWh/sf-yr	Peak W/sf
Heating	BTU/sf-yr	Peak W/sf
Aggregate	kWh/sf-yr (total elec) BTU/sf-yr (site) BTU/sf-yr (source) Utility $/sf-yr	Peak W/sf Effectiveness (Ideal/Actual)

Core information resources

Labs21 Benchmarking Tool – Data Input





Core information resources

Labs21 Benchmarking Tool – Analysis

Benchmarking Labs for the 21st Century Web Toolkit - Microsoft Internet Explorer

Address http://www.dc.lbl.gov/Labs21/CompareData.php?UserID=2

LABS FOR THE 21ST CENTURY

benchmarking

Choose Metrics and Filtering Criteria

More Information

User LBNL
Organization Lawrence Berkeley National Laboratory

Please specify the metric criteria -

System: Total Building
Energy / Efficiency Metric: BTU/sf-yr (site)

Please specify the filtering criteria -

1. Lab Area / Gross Area ratio

is greater than or equal to 0.00 and is less than or equal to 0.99

2. Occupancy

- Standard (≤14 hours)
- High (>14 hours)
- Both (all data)

3. Climate [Climate Code, Climate Type, Representative City]

(To view the map of climatic distribution)

- 1A, **Very Hot - Humid** (Miami, FL)
- 2A, **Hot - Humid** (Houston, TX)
- 2B, **Hot - Dry** (Phoenix, AZ)
- 3A, **Warm - Humid** (Memphis, TN)
- 3B, **Warm - Dry** (El Paso, TX)
- 3C, **Warm - Marine** (San Francisco, CA)
- 4A, **Mixed - Humid** (Baltimore, MD)
- 4B, **Mixed - Dry** (Albuquerque, NM)
- 4C, **Mixed - Marine** (Salem, OR)
- 5A, **Cool - Humid** (Chicago, IL)
- 5B, **Cool - Dry** (Bosie, ID)
- 6A, **Cold - Humid** (Burlington, VT)
- 6B, **Cold - Dry** (Helena, MT)
- 7, **Very Cold** (Duluth, MN)
- 8, **Subarctic** (Fairbanks, AK)

Reset Values   Continue...

Graphing - Microsoft Internet Explorer

Address http://www.dc.lbl.gov/Labs21/Graphing.php

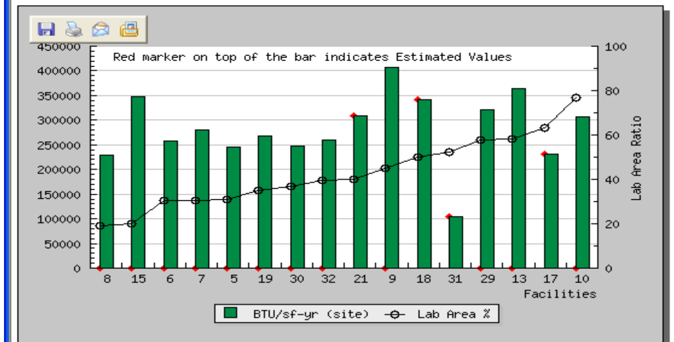
LABS FOR THE 21ST CENTURY

benchmarking

Graphing Data

User	LBNL
Organization	Lawrence Berkeley National Laboratory

Total Building BTU/sf-yr (site)



Facility	Total Building Site Energy Use (BTU)	Gross Area (sq.ft.)	BTU/sf-yr (site)	Lab Area Ratio	Occupancy Hours	Climate
8	12613440000	54962	229493.83	0.19	12	3C
15	184866190404	532602	347100.07	0.2	11	4C
6	14396064000	55903	257518.63	0.3	12	3C
7	12350320000	44152	279722.78	0.31	12	3C
5	21098712000	85761	246017.56	0.31	12	3C
19	40723337460	151435	268916.28	0.35	12	4B
30	5198674400	21018	247343.91	0.37	24	3C

LABS FOR THE 21ST CENTURY

Design process tools

Process Manual

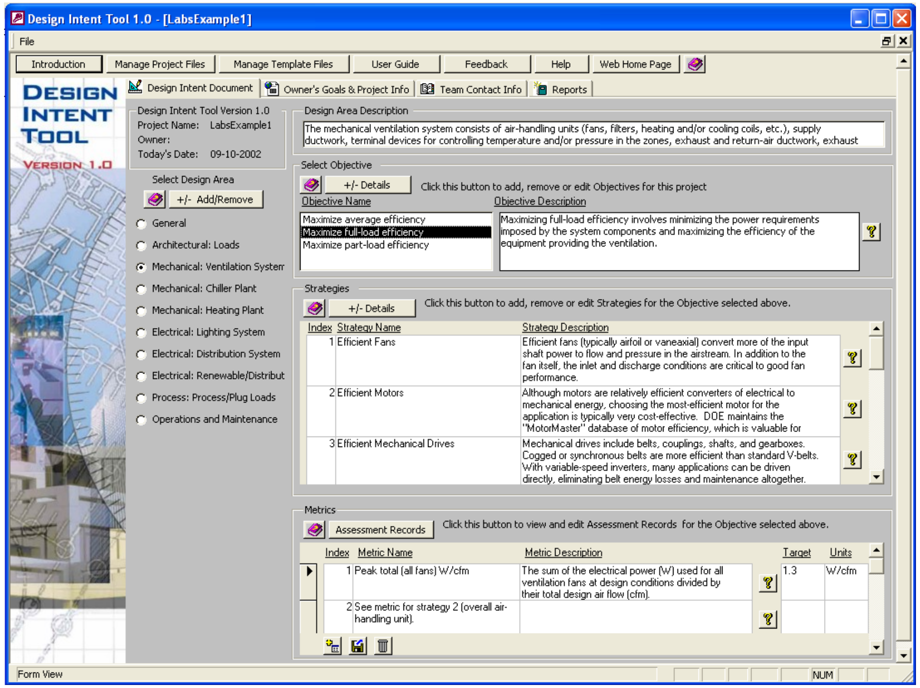
- Purpose: Design process guidance
- Action items for each stage of design process
  - Links to appropriate tools and resources
- Checklist of sustainable design strategies
  - Portal to core information resources
  - Useful for design charrettes
- Access at Labs21 web site or Tool Kit CD

Design process tools

Design Intent Tool

- Purpose: Documentation of Design Intent
  - Structured approach to recording sustainable design strategies, metrics
  - Database tool – MS Access
  - Automated report generation

- Benefits
  - Allows owners and users to verify that design intent is being met.
  - Gives commissioning agents, facility operators, and future renovators an understanding of how the building systems are intended to operate.



Design process tools

Environmental Performance Criteria (EPC)

- A rating system for evaluating laboratory design
  - Builds on the LEED™ rating system
  - Adds credits and prerequisites pertaining to labs
    - Health & safety issues
    - Fume hood energy use
    - Plug loads
- Represents Labs21 perspective on sustainability criteria
  - Public domain document
  - Labs21 does not provide certification process
  - Useful for design charrettes

EPC 2.0 Project Checklist

EPC credits and prerequisites (additions/modifications to LEED) are highlighted

Click on links to see full text for each credit and prerequisite

Yes	?	No			
0	0	0		**Sustainable Sites**	16
Y			Prereq 1	**Erosion & Sedimentation Control**	Required
			Credit 1	**Site Selection**	1
			Credit 2	**Urban Redevelopment**	1
			Credit 3	**Brownfield Redevelopment**	1
			Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
			Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
			Credit 4.3	**Alternative Transportation**, Alternative Fuel Refueling Stations	1
			Credit 4.4	**Alternative Transportation**, Parking Capacity	1
			Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
			Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
			Credit 6.1	**Stormwater Management**, Rate or Quantity	1
			Credit 6.2	**Stormwater Management**, Treatment	1
			Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
			Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
			Credit 8	**Light Pollution Reduction**	1
			Credit 9.1	Safety and Risk Management, Air Effluent	1
			Credit 9.2	Safety and Risk Management, Water Effluent	1
Yes	?	No			
0	0	0		**Water Efficiency**	7
Y			Prereq 1	Laboratory Equipment Water Use	Required
			Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
			Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
			Credit 2	**Innovative Wastewater Technologies**	1
			Credit 3.1	**Water Use Reduction**, 20% Reduction	1
			Credit 3.2	**Water Use Reduction**, 30% Reduction	1
			Credit 4.1	Process Water Efficiency, Document Baseline	1
			Credit 4.2	Process Water Efficiency, 20% Reduction	1
Yes	?	No			
0	0	0		**Energy & Atmosphere**	25
Y			Prereq 1	**Fundamental Building Systems Commissioning**	Required
Y			Prereq 2	Minimum Energy Performance	Required
Y			Prereq 3	**CFC Reduction in HVAC&R Equipment**	Required
Y			Prereq 4	Assess Minimum Ventilation Requirements	Required
			Credit 1.1	Optimize Energy Performance, 5%	1
			Credit 1.2	Optimize Energy Performance, 10%	1
			Credit 1.3	Optimize Energy Performance, 15%	1
			Credit 1.4	Optimize Energy Performance, 20%	1

End of Session

LABS FOR THE 21ST CENTURY